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Mr. Chas. L. Clarke,
Research Laboratory,
General Electric Co.,
Schenectady, N. Y.

November 22, 1929.

IN REPLYING REFER TO

Dear Mr. Clarke:-

Appreciate very much your sending me the Autumn copy of "P.T.M.", also reprint from "Edison's First Commercial Lamp", all of which was very interesting.

Again thanking you and hoping to have the pleasure of meeting you again, I am

Very truly yours,

R. H. McCarroll
Chief Chemist.

R H McCarroll

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Edison's First Commercial Lamp

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By nature, Edison is a maker of history not a historian. Blessed with an inexhaustible store of energy, he forges ahead always intent upon the task of pushing aside the obstacles that lie between him and his next goal. In obtaining the following record of one of his early goals, we are fortunate in having secured Charles L. Clarke as author for he was intimately connected with Edison's work at that time.—EDITOR

EDISON knew on October 21, 1879, after months of intensive effort, that in all its fundamentally essential details he had at last invented an electric lamp to take the place of the ordinary gaslighting burner, and thus had solved the problem popularly known as "subdivision of the electric light" which for years had been talked and written about, often attempted, and even been declared impossible by more than one eminent scientist. He realized he had attained his achievement after discovering the surprising endurance of a carbonized cotton-thread electric burner, when brought up to brilliant incandescence in an all-glass globe exhausted to nearly a perfect vacuum, and made permanently air-tight by having the conducting wires sealed into the glass by fusion.

This first successful incandescent electric lamp was broken open, and thus destroyed, in order that reasons for the remarkable performance of such an attenuated and delicate burner might be found out, as far as the microscope would reveal them. Thus the atmosphere of romance, which has surrounded this lamp by reason of the dramatic suddeness with which it flashed out of a previous darkness in the art of electric lighting, has not attached to its physical self, but is preserved only in the memories of its inventor and Francis Jehl, at that time a laboratory assistant, the last of those now living who heard the "Eureka" which greeted it, and in historical accounts of the lamp and attending circumstances, which preëminently include United States Patent 223,898 for which application was made on the following November 4th, just two weeks after the great discovery, and wherein the outstanding characteristics of a carbonized cotton-thread burner were set forth, and the term "filament" was applied by Edison to his burner, which name still survives for the burners of all incandescent lamps.

In so far as the public was concerned, however, the romance of the Edison lamp was to come just a little later and apply to the so-called horseshoe lamp; the people knew nothing yet of the existence of a successful Edison lamp. In the same November, the inventor, with his inborn railway speed of working, went from cotton thread and various other materials to filaments of carbonized visiting-card bristol board, cut in oval loop-form with enlarged ends for more efficiently connecting the filament with the conducting wires by means of tiny screw-clamps of platinum. The form of these burners gave them the name of "horseshoe" filaments; and the lamps became horseshoe lamps, destined to the honor of being the first commercially used lamps.

Lamps of this character were made as rapidly as limited laboratory facilities permitted; supply wires were strung through the machine shop and laboratory, and overhead on poles to the homes of Edison and some others, and to a few wooden lamp-posts along nearby grass-grown streets in the hamlet of Menlo Park (N. J.), where his laboratory enterprise for research and invention had been established three and a half years before. As fast as lamps were made they were installed at these various places for observation and life-test as well as for practical use.

Soon the rumor began to spread that Edison had made a great invention—an electric light that would supersede gaslighting.

Excitement about it began to grow. At night passengers on Pennsylvania Railroad trains pressed their faces against the windows to see the lamps at the top of the high embankment stairs at Menlo Park station, and a few stray visitors began to filter in, mainly from the region round about; but the visiting continued in increasing volume and from more distant parts, until, on Sunday, December 21st, the *New York Herald* published its famous illustrated article on "Edison's Light," in which the horseshoe lamp was first authentically announced, but incorrectly illustrated, however, with an earlier experimental and discarded means of connecting the filament with the conducting wires. Whereupon Menlo Park became overnight a Mecca for the curious and interested, who came from the cities by thousands during the Christmas season, mainly to see, wonder, and exclaim; for very little, if anything at that day, did they know about the true inwardness of what they saw.

The news about the lamp went round the world; gas stocks tumbled, while stock of the little Edison Electric Light Company mounted to almost fabulous figures. But in all the excitement outside, the Menlo Park establishment remained calm. It still had

wearing work to do that the public knew nothing about; for although the little lamps continued to burn on serenely in gradually increasing numbers there was at first a strange fickleness in their life. With no practically observable difference between them, some lamps failed almost immediately or in a comparatively short time, although most of them encouragingly kept on for perhaps a hundred or several hundred hours, and in a few instances for upward of a thousand hours.

Edison went to work to even things up, to raise the average life with a fairly minimum departure from it, and practically to eliminate quick failures. This was soon satisfactorily accomplished for that time in the art, particularly by improving and systematizing means and method for carbonizing the filaments and exhausting the lamps. The normal life finally attained was around 300 hours.[1] From their thread-like tenuity, combined with the limited elasticity of

TABLE I

PERFORMANCE CHARACTERISTICS

Volts	Amperes	Watts	Ohms	Candle Power Max. Horiz.
0.0	0.0	0.0	123	0
12.654	0.111	1.405	114	0
14.448	0.129	1.864	112	Just visible
18.204	0.164	2.985	111	Dull-red
25.334	0.239	6.055	106	Cherry-red
33.934	0.361	12.250	94	0.016
40.050	0.445	17.822	90	0.10
48.783	0.578	28.197	84.4	0.50
52.584	0.626	32.968	84	0.83
53.728	0.645	34.655	83.3	1.10
55.440	0.672	37.256	82.5	1.5
64.880	0.811	52.618	80	4.5
70.461	0.908	63.978	77.6	9.2
80.386	1.079	86.736	74.5	20.0

carbonized bristol board, however, the filaments continued sensitive to mechanical shock by which they were apt too easily to be broken. Concurrently with this work, Edison was naturally searching for a more durable filament material, both electrically and mechanically, which at the same time would permit operation at still higher incandescence and thus at greater candle-power efficiency.

The horseshoe lamps were, however, performing such good service at Menlo Park that at the urgent desire of Henry Villard, then a director in the Edison Electric Light Company, and president of the Oregon Railway and Navigation Company, a contract was entered into by the two companies under which the new steamship *Columbia* of the latter company was equipped at New York City with a complete Edison lighting plant which included 115 horseshoe lamps, rated at 16 candle power and known as "A" lamps. The installation was started in operation on May 2, 1880, and a few days later the *Columbia* began her voyage around the Horn to the Pacific Coast and arrived at Portland, Oregon, on July 26th, with a cargo of locomotives, cars, and other railway equipment.

The *Columbia's* lighting plant was a perfect success during the long voyage. But in the meanwhile, Edison had found out the far superior virtues of

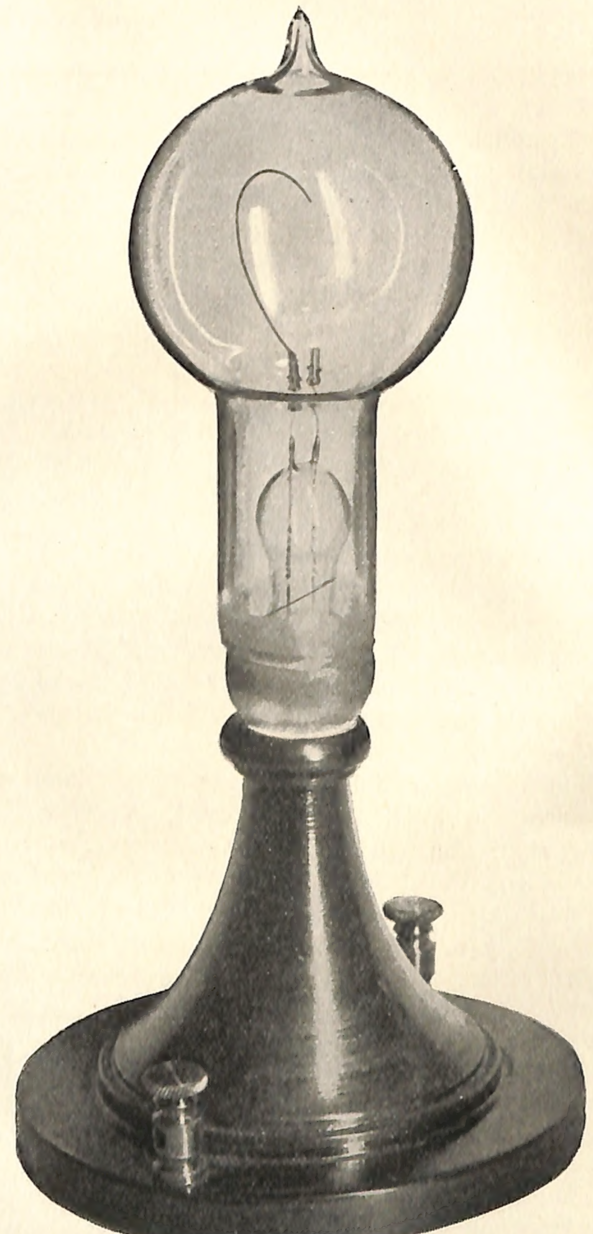

Fig. 1. Photograph of One of the Original Edison Lamps Used in Commercial Service. Lamps of this carbonized bristol-board, "horseshoe" filament type were produced from November, 1879, to May, 1880. In this illustration the lamp is shown approximately ¾ size. Actual dimensions (in inches): total height $8\frac{1}{16}$; diameter of base $3\frac{15}{16}$; bulb diameter $2\frac{5}{16}$; length of bulb neck from bulb to stem seal $1\frac{7}{8}$

carbonized bamboo over bristol board, and had shipped bamboo-filament lamps overland to meet the ship upon her arrival. Thus ended the commercial career of the horseshoe lamp—romantic under all the circumstances, even though brief. It at least filled the commercial bill until a better filament came along. Incidentally, the bamboo lamp continued to be the Edison lamp in common use until 1894.

(1) "Edisonia: a Brief History of the Early Edison Electric Lighting System," New York, 1904. Published by the Association of Edison Illuminating Companies. See p. 103 in an illustrated article on lamps, by William J. Hammer, who was employed in Edison's laboratory.

In the hurly-burly of pushing rapid lamp improvement, coupled with the stress of developing the thousand-and-one other details of his electric central-station system, this energetic doer, Edison, permitted little time and cared less for the systematic recording and sure preservation of what had been done, but was ever disposed to forget the technically old and hasten on to the better new. Consequently, today we should doubtless be at a loss for precise performance data relating to the horseshoe lamp, were it not for tests, by Professor Henry Morton and others at the Stevens Institute of Technology, upon a lamp obtained from Edison through the *Scientific American*. Meager results of the tests were published in that journal, April 17, 1880, but fortunately a complete account was rendered by Professor Morton in an official government report[2] dated at Hoboken (N. J.), November 29, 1880, four months after the horseshoe lamp had been superseded by the bamboo lamp. The report contained a small woodcut of the lamp mounted on a Menlo Park made wooden stand with binding posts (with improper omission of the lamp-bulb tip, however), also a description of test apparatus used and methods of measurement followed, tabulated test results, and curves illustrating the relation of resistance to horizontal-face candle power and to horsepower consumed, relation of candle power to horsepower and relation of angle between plane of filament loop and axis of photometer to candle power.

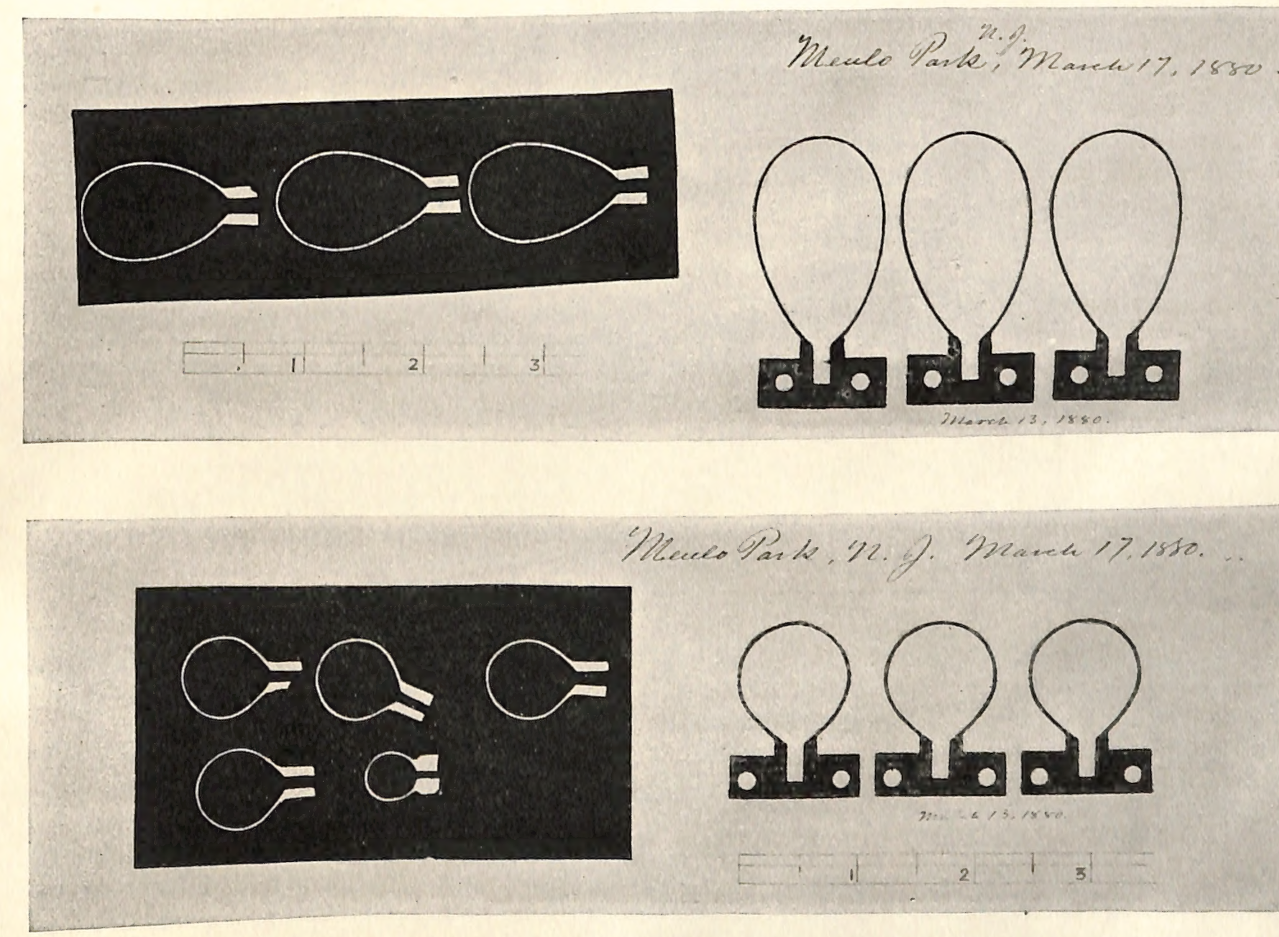

Fig. 2. Records of the Shape and Size of the Bristol-board "Horseshoe" Filaments for Edison's First Commercial Lamp. At the right are impressions of the steel dies used in blanking out the filaments and at the left are contact blue-print impressions of the filaments after carbonizing. The width of the large filaments before carbonizing was 25 mils and the small filaments 30 mils; and the thickness 6.5 mils. Carbonizing produced a linear shrinkage in the ratio of 15 to 11

Table I is derived from tabulated data in the Morton report.

The arithmetical mean of ten candle-power readings, ten degrees apart from face (20.6 candles) to edge (6.7 candles). was 69.2 per cent of the face value.

The accompanying figures may be taken as representing about the average performance characteristics of good horseshoe lamps, bearing in mind that there was more or less variation between individual lamps, especially in respect to voltage required to obtain the nominal 16 candle power. This variation also persisted with the bamboo lamps for the first few years of their commercial introduction, even to the extent of 15 to 20 per cent, or all the way from 95 to 125 volts,

(2) Report on the Electric Light by Professor Henry Morton, Member of the Light House Board. Being the Appendix to the Annual Report of the Board for the year ending June 30, 1880. Washington: Government Printing Office, 1881. The report was docketed: Treasury Department, Document No. 100. *Light House Board.*

which required electric lighting plants to be operated at different voltages because it was impossible to make all the lamps of the desired 110 volts.[3]

A few of the horseshoe lamps are still preserved, one of which is illustrated in Fig. 1. The broken-off piece of filament is seen at the bottom of the bulb neck where it joins the lamp stem, through the top of which platinum leading-in wires are sealed, with little platinum screw-clamps at their upper ends serving to support and make electrical connection with the filament. The lamp is mounted on a replica of one of the wooden stands commonly used to support lamps under test on the laboratory tables. The lamp stem extends downward into the stand about $1\frac{3}{4}$ in. These stands were wont to vary considerably in design according to the fancy of the wood-turner at the moment.

The electrical connections are completed by spirally winding the platinum leading-in wires around larger copper wires going to the binding posts. The glass parts are of lead glass. The bulb was blown from one-inch tubing and, in the lamp here shown, is $2\frac{5}{16}$ in. in diameter. The lamp stem was formed from three-eighth-in. tubing. The total height of such 16-c.p. lamps, called "A" lamps, in their final development was about $6\frac{1}{4}$ in.[4]

In March, 1880, the writer had occasion, at Edison's instance, to figure out certain candle-power characteristics of horseshoe lamps, and in connection therewith, took red ink impressions of the steel cutting molds by means of which the bristol-board filament blanks were cut out by hand with a paring knife, and also made blueprints of the carbonized filaments. These blueprints and impressions are reproduced with accompanying inch scale in Fig. 2.

The molds were made in like halves, with the bristol-board screw-clamped between them; this left the cutout filament blank with a connecting piece at the base, which was trimmed off before carbonizing. The largest filaments in the illustration were for the "A" lamps of 16 candle-power nominal rating, as shown in Fig. 1. The filaments of intermediate size were for half-voltage "B" lamps of eight candle-power rating, primarily intended for use with two in series on a full voltage "A" lamp circuit; while the smallest filament was for four-candle lamps for use four in series. The lamps of less than standard full candle power were only tentatively tried out because in the rush of development there was no time then to do more with them. But the principle of using lamps of fractional voltage and candle power in series on a system of standard higher voltage and candle power, then established by Edison, was commercially applied on a considerable scale after introduction of the bamboo lamp.

By carbonization the bristol board shrank linearly in the ratio of 15 to 11. The length of the "A" carbon filament was 2.95 in.; face surface, 0.054 sq. in.; width, 18.33 mils; and thickness 4.77 mils. The length of the "B" filament was 1.92 in.; face surface, 0.0423 sq. in.; width, 22 mils and thickness 4.77 mils. The writer does not happen to have preserved from his Menlo Park days any substantial record of the four-candle lamp other than the blueprint impression of its filament shown in Fig. 2.

The economy of this first commercial lamp may today seem exceedingly low, amounting to about 4.9 watts per horizontal-face candle at 16 candle-power rating, with an average life of about 300 hr. as compared with the successively greater economies finally attained with the bamboo-carbon lamp, followed by the Gem metallized carbon filament lamp, culminating in the modern drawn-tungsten filament lamps, which for comparison represent an economy of better than one watt per equivalent horizontal candle in the Mazda B (vacuum) lamp, and from 8/10 to 3/10 watt in the Mazda C (gas-filled) lamp, depending upon its candle-power size, all coupled with an increase in rated life to 1000 hr.

Nevertheless, in the brilliant light of today's achievements in improving upon the first commercial lamp our hindsight must not be so dimmed thereby as to prevent an acute and lasting perception of the fact that Edison's horseshoe lamp with its carbonized bristol-board filament was the original sprout from the seed sown by his discovery and invention of October 21, 1879, which demonstrated that the seed had commercial life, and started its growth and spread throughout the world.

(3) "History of the Incandescent Lamp," by John W. Howell and Henry Schroeder, General Electric Co., Schenectady, N. Y., 1927, p. 78.

(4) An outline drawing of the lamp in exact size, minus small details, was published in *Scribner's Monthly*, February, 1880, in an article on "Edison's Electric Light," by Francis R. Upton, one of Edison's assistants at the time.